

REMARKS

Claims 33-64 are pending, with claims 33-50 under current examination and claims 51-64 withdrawn from consideration. Applicants have amended independent claim 33. Support for the amendments to claim 33 can be found in the specification at, for example, p. 4, lines 1-3, p. 17, line 25 to p. 18, line 6, and Figures 10(a), 10(b), and 11.

Final Office Action

Applicants respectfully traverse the following rejections set forth in the Final Office Action:

(a) rejection of claims 33-50 under 35 U.S.C. § 103(a) as being unpatentable over Kim et al., “Cu-Ni Cermets for Direct Oxidation of Methane in Solid-Oxide Fuel Cells” (“Kim”) in view of U.S. Patent No. 4,423,122 (“Iacovangelo”);

(b) rejection of claim 48 under 35 U.S.C. § 103(a) as being unpatentable over Kim in view of Iacovangelo and further in view of U.S. Patent App. Pub. No. 2002/0061429 (“Batawi”); and

(c) rejection of claim 49 under 35 U.S.C. § 103(a) as being unpatentable over Kim in view of Iacovangelo and further in view of Livermore et al., “Fuel Reforming and Electrical Performance Studies in Intermediate Temperature Ceria-Gadolinia-Based SOFCs” (“Livermore”).

Rejection of Claims 33-50 under 35 U.S.C. § 103(a):

Applicants request reconsideration and withdrawal of the rejection of claims 33-50 under 35 U.S.C. § 103(a) as being unpatentable over Kim in view of Iacovangelo. The Final Office Action has not properly resolved the *Graham* factual inquiries, the proper resolution of which is the requirement for establishing a framework for an objective obviousness analysis. See M.P.E.P. § 2141(II), citing to *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), as reiterated by the U.S. Supreme Court in *KSR International Co. v. Teleflex Inc.*, 550 U.S. 398, 82 USPQ2d 1385 (2007).

Particularly, the Final Office Action has not properly determined the scope and content of the prior art, at least because the Final Office Action incorrectly interpreted the content of Kim and Iacovangelo. In addition, the Final Office Action has not properly ascertained the differences between the claimed invention and the prior art, at least because the Final Office Action has not properly interpreted the prior art by considering both the invention and the prior art as a whole. See M.P.E.P. § 2141(II)(B).

Claim 33 recites “[a] solid oxide fuel cell” (SOFC). According to amended claim 33, the SOFC includes “a cathode,” “at least an electrolyte membrane,” and “an anode for oxidizing a fuel.” The anode for oxidizing the fuel includes “a ceramic material and an alloy comprising nickel and at least a second metal.” The alloy includes “alloy particles having an average particle size not lower than 1 nm and not higher than 20 nm.” Furthermore, the “ceramic material comprises ceramic material particles exposed to the fuel to form a three-phase boundary when the fuel is fed to the anode.”

Kim and Iacovangelo, taken alone or in combination, do not teach or suggest each and every feature of amended independent claim 33. For example, the cited references do not teach or suggest “an alloy . . . compris[ing] alloy particles having an average particle size not lower than 1 nm and not higher than 20 nm,” as recited in amended claim 33. The Final Office Action admits that “Kim . . . neither expressly disclose the specific particle size of both the alloy and the ceramic material nor the mean surface area.” Final Office Action, p. 4. The Final Office Action then relies on Iacovangelo to allegedly cure the deficiencies of Kim. The Final Office Action made the following allegations, among others, with respect to Iacovangelo:

Iacovangelo et al disclose . . . particle size of the nickel-copper alloy ceramic material ranges from about 0.1 micron to about 20 microns (COL 2, lines 20-35/COL 3, lines 3-7). Iacovangelo et al further disclose that the specific size/thickness of the Ni-Cu

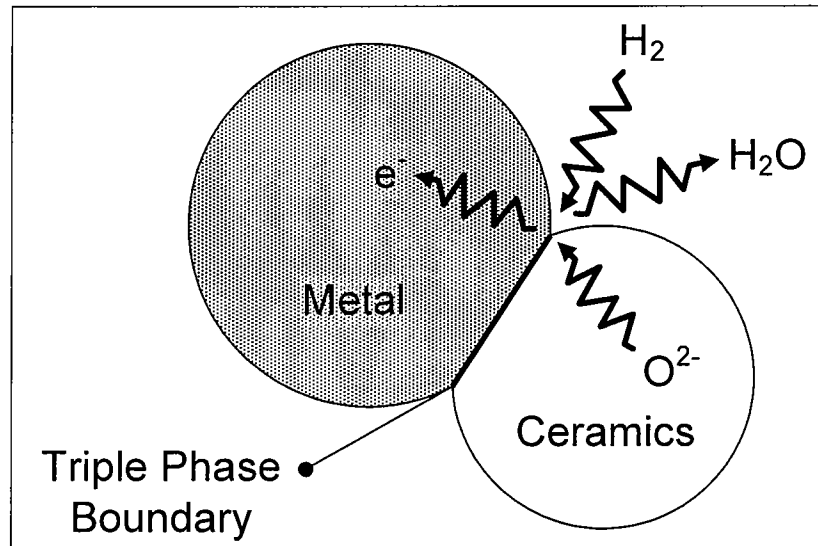
depends largely on the size of the ceramic powder (Col 2, lines 63-67).

In this case, the particle size of the nickel-copper alloy encapsulated ceramic particle material is taken to represent the particle size of both the alloy and the ceramic material as Iacovangelo et al does not appear to make a distinction between one and the other.

Final Office Action, p. 4 (emphasis added). Iacovangelo, however, relates to a molten carbonate fuel cell, which is completely different from a solid oxide fuel cell as recited in claim 33, or a solid oxide fuel cell as taught in Kim. To explain the differences between these two types of fuel cells, Applicants provide the following explanations.

As well known in the art and as described in Applicants' specification, the basic structure of a solid oxide fuel cell (SOFC) includes a cathode, a solid oxide electrolyte membrane, and an anode. At the cathode, oxygen reduction takes place which generates negative oxygen ions. The negative oxygen ions formed at the cathode are conducted from the cathode to the anode through the solid oxide electrolyte membrane. At the anode, an oxidation reaction of the oxygen ions with a fuel (*e.g.*, hydrogen or carbon monoxide) occurs so as to generate electrons, water, and *e.g.*, carbon dioxide. The electrons are collected to generate electric energy.

During the oxidation reaction, three materials are present in the anode according to the claimed invention: the ceramic material that conducts the negative oxygen ions, the alloy material that conducts the electrons generated by the oxidation reaction, and the fuel. In order to maximize the efficiency of the oxidation reaction at the anode and the performance of the fuel cell, the boundary among the three materials, known in the art as the three-phase boundary or "TPB," has to be maximized. To facilitate an understanding of the three-phase boundary, Applicants include the following explanatory figure showing the three-phase boundary:



According to the claimed invention, in order to enable the oxidation reaction of the oxygen ions, which are conducted by the ceramic particles, with the fuel, it is important that the ceramic particles are exposed to the fuel.

In contrast, Iacovangelo relates to a completely different fuel cell. Iacovangelo discloses “a porous sintered electrode useful for a molten carbonate fuel cell.” Iacovangelo, col. 2, lines 20-22. A molten carbonate fuel cell is different from a solid oxide fuel cell. A molten carbonate fuel cell (MCFC) includes a cathode (*see Iacovangelo*, e.g., col. 2, line 4), an electrolyte (*see id.*, e.g., col. 5, line 16), and an anode (*see id.*, e.g., col. 1, line 66). The electrolyte is composed of a molten carbonate salt mixture suspended in a porous, chemically inert ceramic matrix. *See id.*, e.g., col. 2, lines 35-49. At the cathode, oxygen and carbon dioxide react to form negative carbonate ions. *See Iacovangelo*, col. 2, lines 4-6. The negative carbonate ions formed at the cathode are conducted from the cathode to the anode by the molten carbonate salt mixture of the electrolyte. At the anode, hydrogen in the fuel gas reacts with negative carbonate ions from the electrolyte to form electrons, water, and carbon dioxide. *See id.*, col. 1, lines 64-68.

In a molten carbonate fuel cell, the ceramic material is chemically inert and does not participate in the reactions at the electrodes. *See Iacovangelo*, col. 2, line 46. Indeed,

Iacovangelo discloses an electrode composed of nickel copper alloy encapsulated ceramic particles. *See id.*, col. 2, line 23. Iacovangelo discloses that the “ceramic particles must be electroless plated since they must be completely enveloped, i.e., encapsulated by the metal coating [*i.e.*, the nickel and copper alloy,] or at least substantially completely enveloped with [the] metal coating so that there is no significant exposure of the ceramic particle surface.” *Id.*, col. 3, lines 45-50 (emphases added).

Therefore, the ceramic particles disclosed in Iacovangelo do not constitute “ceramic material particles exposed to the fuel to form a three-phase boundary when the fuel is fed to the anode,” as recited in amended claim 33 (emphasis added).

Furthermore, Iacovangelo’s “ceramic particle ranges in size from about 0.1 micron to about 20 microns” (*see id.*, col. 3, lines 4-6), which is equivalent to about 100 nm to about 20,000 nm, a range that is outside of the claimed range of “not lower than 1 nm and not higher than 20 nm,” as recited in amended claim 33.

One of ordinary skill in the art would therefore appreciate that a molten carbonate fuel cell as disclosed in Iacovangelo is technically distinct from a solid oxide fuel cell as disclosed and claimed. Therefore, a person of ordinary skill in the art would not have been motivated to refer to Iacovangelo in the expectation to find any reasonable suggestion for improving the solid oxide fuel cell disclosed, for example, in Kim. Indeed, Iacovangelo provides no suggestion that reducing the particle size of the alloy would result in no carbon formation, as recognized by Applicants. Accordingly, the Final Office Action’s allegation that it would have been obvious for one of ordinary skill in the art to modify Kim using the teachings of Iacovangelo is based on improper hindsight reasoning.

Furthermore, even assuming, for the sake of argument, that the teachings of Iacovangelo were applied to the solid oxide fuel cell disclosed in Kim, one of ordinary skill in the art would at

most have arrived at an anode including ceramic particles that are completely or substantially completely encapsulated by the nickel and copper alloy, which are not exposed to the fuel as claimed. One of ordinary skill in the art would not have arrived at an “alloy compris[ing] alloy particles having an average particle size not lower than 1 nm and not higher than 20 nm, and . . . [a] ceramic material compris[ing] ceramic material particles exposed to the fuel to form a three-phase boundary when the fuel is fed to the anode,” as recited in amended claim 33 (emphases added).

Moreover, applying the teachings of Iacovangelo, related to a molten carbonate fuel cell, to the solid oxide fuel cell disclosed in Kim would have changed the principle of operation of the solid oxide fuel cell of Kim, or would have rendered Kim’s solid oxide fuel cell unsatisfactory for its intended purpose. See M.P.E.P. § 2143.01(V) and (VI). This is because Iacovangelo’s ceramic particles are completely or substantially completely encapsulated by the nickel and copper alloy, and therefore, are not exposed to the fuel. In contrast, Kim’s solid oxide fuel cell requires that the ceramic particles be exposed to the fuel.

For the foregoing reasons, the teachings of Iacovangelo cannot be combined with the teachings of Kim. Moreover, even if the teachings of Iacovangelo are combined with the teachings of Kim, Iacovangelo still does not cure the deficiencies of Kim.

With respect to the claimed alloy particle size, the Final Office Action contends that “[g]enerally speaking, differences in sizes or dimension will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such size or dimension is critical.” Final Office Action, p. 5 (emphasis added). See also M.P.E.P. § 2144.05(II)(A).

Applicants note that the specification has provided sufficient evidence indicating that reducing the size of the alloy particles is critical in affecting carbon formation. For example, the

specification describes a comparison between the results obtained with a solid oxide fuel cell disclosed in Applicants' invention (*see* specification, pp. 13-18, Examples 4 and 6-9) and the results obtained with a solid oxide fuel cell prepared according to Kim (*see* specification, p. 14, Example 5).

In particular, by following the teachings of Kim for preparing a $\text{Ni}_{0.5}\text{Cu}_{0.5}\text{-CGO}$ (50:50 w/w) cermet (*see* Kim, p. A247, "Experimental" chapter), Applicants obtained a cermet having an alloy particle size of 26 nm (*see* specification, p. 14, Table 2, Example 5). When reduced in H_2 at 1,173 °K (900 °C) for 3 hours, and then exposed to flowing CH_4 at 1,073 °K (800 °C) for 1.5 hours, this cermet showed carbon formation. *See* Kim, Figure 1, and p. A248, col. 1, lines 10, stating that "[t]he Cu-Ni alloys all showed some carbon formation."

In contrast, the cermet ($\text{Ni}_{0.58}\text{Cu}_{0.42}\text{-CGO}$ (50:50 w/w)) prepared according to the Example 4 of Applicants' disclosure has an alloy particle size of 15 nm, which is smaller than the size of 26 nm for the alloy prepared in Example 5 according to the teachings of Kim. *See* specification, p. 14, Table 2. With the alloy particle size of 15 nm, the cermet prepared according to Applicants' Example 4 showed no carbon formation either after an operation at 800 °C under SOFC conditions with a current density of 250 mA cm^{-2} for 20 hours, or after an operation at 700 °C for 50 hours. *See* specification, p. 18, lines 7-17. Likewise, the $\text{Ni}_{0.58}\text{Cu}_{0.42}$ alloy prepared according to Applicants' Example 1 has a particle size of 19.2 nm (*see* specification, p. 11, Table 1, last row), which is also smaller than the size of 26 nm for the alloy prepared in Example 5 according to the teachings of Kim. For the alloy prepared according to Example 1, there is also no evidence of carbon deposition. *See* specification, p. 13, discussion of Example 3, lines 19-22.

Applicants' disclosure indicates that an alloy prepared according to the teachings of Kim and having a particle size of 26 nm would lead to carbon formation. In contrast, an alloy

prepared according to the claimed invention and having a particle size of less than 26 nm would not lead to carbon formation. Thus, Applicants' disclosure has provided sufficient evidence indicating that the size of the alloy particle is critical in affecting carbon formation.

In fact, as discussed in Applicants' specification, that by reducing the average size of the alloy particle, the reduction in the deposition of graphite fibers is "particularly surprising since a reduction of the average particle size in the metallic component of the cermet would have been expected to increase the catalytic activity also with respect to those side reactions which cause formation of the graphite fibers." Specification, p. 3, lines 18-22. Applicants have recognized that reducing particle size of the alloy to no more than 20 nm would lead to no carbon formation, a concept that is contrary to the common knowledge in the art at the time the application was filed.

Thus, the Final Office Action has neither properly determined the scope and content of the prior art, nor properly ascertained the differences between the claimed invention and the prior art. Independent claim 33 is therefore nonobvious over Kim and Iacovangelo. Independent claim 33 should therefore be allowable. Dependent claims 34-50 should also be allowable at least by virtue of their dependence from base claim 33, and because they recite additional features not taught or suggested by Kim and Iacovangelo. Applicants therefore respectfully request reconsideration and withdrawal of the 35 U.S.C. § 103(a) rejection.

Remaining Rejections of the Dependent Claims under 35 U.S.C. § 103(a):

Applicants respectfully request reconsideration and withdrawal of the remaining rejections of dependent claims 48 and 49 under 35 U.S.C. § 103(a) over Kim in view of Iacovangelo and further in view of one or more of secondary references Batawi and Livermore.

As discussed above, Kim and Iacovangelo do not teach or suggest each and every feature of independent claim 33. Batawi and Livermore, whether taken alone or in any combination

with Kim and Iacovangelo, do not remedy the deficiencies of Kim and Iacovangelo as to the features of independent claim 33. For example, Batawi and Livermore, whether taken alone or in any combination with Kim and Iacovangelo, do not teach or suggest “[an] alloy compris[ing] alloy particles having an average particle size not lower than 1 nm and not higher than 20 nm, and . . . [an] ceramic material compris[ing] ceramic material particles exposed to the fuel to form a three-phase boundary when the fuel is fed to the anode,” as recited in amended independent claim 33.

Thus, independent claim 33 is nonobvious over Kim and Iacovangelo in view of one or more of secondary references Batawi and Livermore, regardless of whether these references are taken alone or in any combination. Claim 33 should therefore be allowable. Dependent claims 48 and 49 should also be allowable at least by virtue of their respective dependence from base claim 33, and because they recite additional features not taught or suggested by the cited references. Accordingly, Applicants respectfully request reconsideration and withdrawal of the remaining 35 U.S.C. § 103(a) rejections.

Conclusion

Applicants request reconsideration of the application and withdrawal of the rejections. The pending claims are in condition for allowance, and Applicants request a favorable action.

The Final Office Action contains a number of statements reflecting characterizations of the prior art, alleged inferences to be drawn therefrom, case law, and the related claims. Regardless of whether any such statements are identified herein, Applicants decline to automatically subscribe to any such statements or characterizations in the Final Office Action.

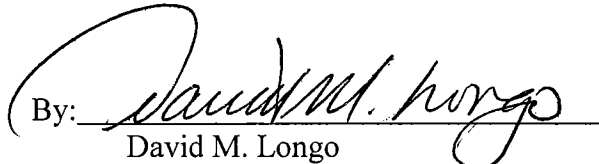
If there are any remaining issues or misunderstandings, Applicants request the Examiner telephone the undersigned representative to discuss them.

Please grant any extensions of time required to enter this response and charge any additional required fees to our deposit account no. 06-0916.

Respectfully submitted,

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Dated: June 30, 2010

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